REMARKS

This Preliminary Amendment cancels original claims 1 to 11 in the underlying PCT Application No. PCT/DE03/03103 and adds new claims 12 to 23. The new claims conform the claims to the U.S. Patent and Trademark Office rules and do not add new matter to the application.

In accordance with 37 C.F.R. § 1.125, the Substitute Specification (including the Abstract, but without the claims) contains no new matter. The amendments reflected in the Substitute Specification (including the Title and Abstract) are to conform the Specification and Abstract to U.S. Patent and Trademark Office rules or to correct informalities. As required by 37 C.F.R. § 1.121 and § 1.125, a Marked Up Version Of The Substitute Specification comparing the Specification of record and the Substitute Specification also accompanies this Preliminary Amendment. In the Marked Up Version, underlining indicates added text and "strike-throughs" and double-brackets indicate deleted text. Approval and entry of the Substitute Specification (including Abstract) are respectfully requested.

Also enclosed is a translated copy of the International Search Report dated January 14, 2004. The Search Report includes a list of documents that were considered by the Examiner in the underlying PCT application.

It is asserted that the subject matter of the present application is new, non-obvious, and useful. Prompt consideration and allowance of the application are respectfully requested.

Respectfully Submitted,

KENYON & KENYON

Dated: 6/6/05
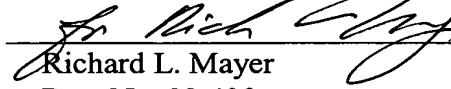
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DEVICE FOR MEASURING ANGULAR POSITIONS

FIELD OF THE INVENTION

The present invention relates to a device for measuring angular positions using radar pulses having mutually overlapping beam characteristics of at least two antenna elements.

~~Background Information~~

5   BACKGROUND INFORMATION

Radar sensors for recording the nearby motor vehicle environment (SRR, short range radar sensors) ~~are~~may be provided for functions such as backup aid, parking assistance, parking gap measurement, blind spot monitoring, slow bumper to bumper driving or precrash detection.

10   Besides the information on the distance of relevant objects (other vehicles, traffic lane limitations or parking gap limitations, pedestrians, ...) information on their angular position relative to the vehicle ~~is~~may also be important for judging the relevance of detected objects for whatever the vehicle is doing. ~~The state of technological development is to calculate~~In this regard, the angular direction of objects may be calculated via so-called trilateration. In

15   this method, the distance data of several neighboring sensors are used in order also to determine the angular deviation of targets, using simple trigonometric conversions. ~~The disadvantage of~~With this method ~~is that~~more and more sensors ~~are~~may be required at a certain distance apart, even to ascertain the position of only one target. Then too, these sensors in each case have to detect the same target, so as not to obtain faulty estimations.

20   ~~From~~International Published Patent Application No. WO 00/~~49423,~~49423 describes a monopulse phase array antenna system~~ is known~~, which has transmitting and receiving modules which are controlled by a beam swivel control device. From the received signals from the various antenna elements, composite signals and angular differential signals are derived. Each of the transmitting and receiving modules is furnished with two 180^0 phase

25   shifters, in order to determine the angular differential signals. For the independent tracking in the azimuth and elevation direction~~ it is known that~~, one may evaluate a composite signal and two differential signals.

~~From~~ M. Skolnik, Introduction to Radar Systems, second edition, McGraw Hill Book Company, 1980, pages 160 and ~~161 it is known~~161, discuss that one may obtain the angular information of a target object from two mutually overlapping antenna beam characteristics.

~~Summary of the Invention~~

5   SUMMARY OF THE INVENTION

~~Using the device according to the features of Claim 1, it is possible to obtain~~According to an exemplary embodiment of the present invention, angular data may be obtained from an overall radar position finding field, at a very limited additional hardware expenditure.

~~Advantageous embodiments are shown in the dependent claims.~~

10   ~~Using the measures~~ According to an exemplary embodiment and/or exemplary method of the present invention, it ~~is~~may not be necessary to provide in each receiving path a separate down converter and separate NF processing. ~~Using the present invention, it is possible to implement the~~The measurement of angular positions may be implemented even using a single sensor. Compared to an implementation that is used only for distance measurement, the

15   position finding field may remain virtually unchanged. The additional hardware expenditure ~~is~~may be limited to a simple phase shifter having a simple signal evaluation.

Because of the angular measurement according to an exemplary embodiment and/or exemplary method of the present invention, ~~it is possible to minimize~~ the number of sensors required may be minimized for certain functions. A backup aid may be equipped with only

20   one angle measuring SRR sensor, whereas conventional systems may require three sensors. At slow bumper to bumper driving, only one or two sensors ~~would~~may be necessary using ~~the~~an exemplary implementation according to the present invention instead of three or four sensors, as in conventional systems. One sensor ~~is~~may be sufficient for blind spot monitoring, instead of two ~~that are usual otherwise~~.

25   ~~Brief Description of the Drawings~~

~~In the following, exemplary embodiments of the present invention are explained with reference to the drawings. The figures show:~~

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows an implementation according to an exemplary embodiment of the present

30   invention having a dual beam antenna and a switchable phase shifter~~;~~.

Figure 2 shows the amplitude curve of a dual beam sensor~~;~~.

Figure 3 shows the phase curve of a dual beam sensor~~;~~.

Figure 4 shows a dual beam antenna with wiring.

~~Figure 5a and b~~ Figures 5a and 5b show dual beam antennas having an 180^0 hybrid (rat race).

Figure 6 shows an antenna system having 2x2 columns for time-division multiplex operation.

Figure 7 shows the antenna system as in Figure 6 having an 180° hybrid.

DETAILED DESCRIPTION

~~Description~~According to an exemplary embodiment and/or exemplary method of the ~~Exemplary EmbodimentsIn the~~present invention, ~~the known~~a radar monopulse technique ~~is~~may be used for angular measurement, in which information about the angular deviation is able to be derived via the comparison of received signals in different, mutually overlapping beam lobes and knowledge of the radiation characteristics themselves (comparable to so-called "best fit matching" of the received signals). This exemplary evaluation method ~~is very~~may be similar to the one used also in long range radar (LRR, ACC). In LRR radar, three or four reception lobes are formed, and their mutual overlapping is drawn upon for the angle estimation using the comparison of the received signals.

In ~~the~~an exemplary device according to the present invention for measuring angular positions, two different receiving characteristics are generated having as widely overlapping areas as possible. To do this, according to Figure 1, at least two antenna elements 1 and 2 are used, each having adjustable oscillation phases. The different phase conditions are produced by an interposed HF component, and in the example according to Figure 1 this is a switchable phase shifter 3, which is interposed in one of the two antenna paths shown here. By switching phase shifter 3, the oscillation phase of antenna element 2 is set differently from that of antenna element 1, whereby the directivity characteristics of the overall system may be considerably influenced. The signals of both antenna elements 1 and 2 in the reception path are subsequently brought together additively (summation node 8) and supplied to a mixer unit 4 (mixture with a mixing oscillator LO) and to further processing (filtering 5, analog/digital conversion (ADC) 6, evaluation device 7).

Figure 2 shows, for example, for a simple model of a patch antenna (for other antenna element characteristics, slightly different beam characteristics come about) the amplitude characteristics of the overall system for both switching conditions of phase shifter 3. The characteristics of beam 1 come about because of the in-phase control of both antenna elements, i.e. phase shifter 3 is in switching state 0^0 (beam 1 = composite beam or in-phase beam). Thereby, in the main beam direction, a maximum forms in the common beam characteristics, by the constructive superimposition of in-phase components. Beam 2 is

obtained by a phase shift of 180⁰ in the path of antenna element 2 (or 1), and in the main beam direction, the components of antenna elements 1 and 2 thereby exactly cancel each other (destructive superimposition), so that the direction characteristics in this direction form a zero point (beam 2 = difference beam or push-pull beam). The result on the side is a

5   symmetrical forming of two main lobes that are identical in the ideal case. Figure 3 shows the appertaining phase curves of both receiving characteristics. While the phase of beam 1 is (mirror) symmetrical to the main beam direction for reasons of symmetry, a centrosymmetric curve comes about for beam 2. This is decisive for the intended angle determination of a target, because a decision is only possible by the non-symmetry of at least one of the two

10   phase curves, as to whether there is a target to the left or to the right with respect to the orientation of the sensor.

For the angle determination itself, back and forth switching takes place between the two phase states, and thereby between the two directivity characteristics (operation in time-division multiplexing). This switching takes place so rapidly that the influence of

15   amplitude changes and phase changes of the incident wave front of a target as a result of relative motions of the target (target fluctuations) or of the transmitter with respect to the receiving antenna is negligible or is still able to be compensated for by appropriate correcting measures. Only then ~~is~~may it be possible to have sufficiently accurate information about which portion of a relative amplitude change and phase change of both directivity

20   characteristics in the receiving channel is ~~clearly~~ to be apportioned to the angular deviation of the target, and not perhaps to other effects named above. On the other hand, the switching period should also not be too small, since otherwise the ~~very~~ cost-effective approach of the direct mixing of the HF carrier signal into the NF baseband (the so-called homodyne formulation, baseband frequency portions in the kHz range) ~~would~~may have to be

25   appropriately modified. To obtain the optimal switching frequency between the antenna characteristics, the relative motions of targets or sensor carriers (one's own vehicle) have to be negligible or able to be compensated for in the evaluation (target angle estimation), (determining for the upper limit of the switching period) but on the other hand a homodyne formulation (determining for the lower limit of the switching period). At HF carrier

30   frequencies in the GHz range, switching periods in the range of a few μs, e.g. 5 to 50 μs ~~are advantageous~~may be desired.

If these time-related effects (target fluctuations, relative motions) are minimal or if they are appropriately compensated for or taken into consideration by correcting variables, the angle of the target is given by a comparison of the relative amplitude change and phase change in

35   the receiving path in both switching states having the two complex-valued directivity characteristics of the antenna system (composite and differential beam). Over the entire angle range, in order that no ambiguities shall appear with respect to the comparison of the received signals to the directivity characteristics, additional lobes (secondary lobes) in beams 1 and 2

should be avoided. This is~~is~~may be possible if, for example, the distance d of the two antenna elements (see Figure 1) is within the range of the half wavelength, for instance, at 24 GHz approximately 6.5 mm.

Figure 4 shows ~~a specific~~ an exemplary embodiment in which the two antenna elements 1 and 2 are formed here, for example, in each case by four radiating elements. These have the task, at vertical positioning to the roadway surface after being assembled in the vehicle, to focus the energy in the vertical direction (elevations focusing) in order thereby to attain an appropriate range, but also in order not to receive reflections from the roadway that are too strong. In the horizontal plane (azimuth) only minor focusing comes about per column, so that the directivity diagrams in the azimuth are very broad, similar to the ones in Figure 2, in order to obtain a horizontal detecting range that is as big as possible, and especially here too, to have an overlapping of the two directivity diagrams that is as broad as possible.

The sketched feedthroughs 9 in Figure 4 have the task of concentrating the HF components which require component assembly, such as the 180^0 phase shifter 3, in the plane or rather on the layer where still further assemblies are required (mixer 4, etc), so that a double-sided assembly may be avoided. In this exemplary embodiment, filter 5 is a low-pass filter TP, provided that the radar sensor principle is based on a homodyne set-up, that means that the received signal is both transmitted using an oscillator (not shown here) and also mixed directly into the baseband (direct conversion). Other ~~specific~~exemplary embodiments ~~are also possible~~may be provided, such as a heterodyne set-up having mixing in an intermediate frequency plane via additional oscillator, with the filter then designed as a bandpass.

Figure 5a shows still another ~~possibility~~exemplary embodiment of how the angle determination according to the type described above may be made. As the phase-setting element, a so-called 180^0 hybrid 10 is used, which in the literature is called a rat race. This has the property of uniformly subdividing a signal incident at a gate to the gates lying opposite to it, and at a relative phase difference of 180^0, while the fourth gate is isolated. Because of the reciprocity and linearity of this component, it ~~is~~may be possible, in ~~exactly~~the same ~~way~~manner, to emit two signals to two input gates and to pick off, at the two gates lying opposite to this, the composite signal and the differential signal, that means, in this case, the composite beam and the differential beam. What ~~is advantageous~~may be desired in this approach is that both beams are present at the same time, so that the negative influence of target fluctuations or relative motions does not appear here. ~~The disadvantage is~~An undesired feature may be that both gates each require one mixer of their own, one filter and one AD converter (hardware expenditure).

Alternatively, the two gates of the rat race may also be supplied to a mixer in time-division multiplexing via a suitable transfer switch (Figure 5b).

Figures 6 and 7 further show ~~exemplary~~ embodiments having two columns each per antenna element. By an ~~exemplary~~ embodiment having more than one antenna column per antenna element, ~~it is possible to obtain~~ a concentration of the received energy ~~may be provided~~ in a horizontal plane. In this manner, a greater antenna gain, and thus a greater radar operating

5   range ~~is achievable~~~~may be acheived~~, whereas the overlap area of composite beam and differential beam ~~are~~~~may be~~ hemmed in thereby. This may be ~~advantageous~~~~desired~~ for functions like, for instance, backup assistance. This ~~exemplary~~ embodiment may also be ~~advantageous~~~~desired~~ for certain functions in which a certain suppression of signals (disturbing station) in the side region is rather desirable, e.g. from guardrails or other

10   developments at the edge of the roadway. This is directly supported by the strong focusing of multi-column antenna elements.

Phase shifter 3 may ~~advantageously~~ be developed as PIN diode phase shifter.

A radar sensor according to ~~an exemplary embodiment of~~ the present invention may include, in ~~a highly~~~~an~~ integrated ~~design~~~~configuration~~, the phase shifter or possibly the transfer switch,

15   the signal junction (T junction, Wilkinson divider, or others), the mixer and possibly additional low-noise preamplifiers (LNAs) in an MMIC (monolithic microwave integrated circuit).

As phase shifter 3 one may also use an RF MEMS 180^0 phase shifter (RF radio frequency, MEMS = microelectromechanical system).

20   The antenna elements may be provided in various ~~designs~~~~configurations~~: radiating element, columns, several columns jointly per antenna element, so-called patch radiators, etc.

As transfer switch 11, PIN diode switches or MEMS switches may be used.

~~Abstract~~ <u>ABSTRACT</u>

In a device for measuring angular positions by using radar pulses and mutually overlapping beam characteristics of at least two antenna elements ~~(1, 2)~~, a switchable phase shifter ~~(3)~~ is provided in the signal path of at least one antenna element which is switchable in the time-

5   division multiplexing between different phase states. For the radar received signals, an evaluation device ~~(7)~~ is provided for the joint and especially simultaneous evaluation of signals of two antenna elements ~~(1, 2)~~ with the participation of antenna element ~~(2)~~, in whose signal path a switchable phase shifter ~~(3)~~ is provided.

~~(Figure 1)~~